ALUMINA TRIHYDRATE (ATH) & MAGNESIUM HYDROXIDE (MDH)

WHY GO ANYWHERE ELSE?
Huber Engineered Materials is part of J.M. Huber Corporation. With $2 billion in annual sales, the Huber family of solutions represents diversification and financial strength.
For over 25 years, Huber has been a trusted supplier of alumina trihydrate (ATH) and, more recently, magnesium hydroxide (MDH) products for flame retardant applications. Recognized as a leader in type and volume of grades of these versatile additives, Huber began its ATH operations with the acquisition of Solem Industries in 1981. Since then, Huber’s manufacturing focus has been centered on expanding its manufacturing capacity, product offerings, research and technical service resources and surface treating technology.

In 2005, Huber bolstered its position in the marketplace with the acquisition of AluChem Inc.’s ATH business.

With ATH supply relationships worldwide to ensure availability and uninterrupted delivery, Huber’s ATH and MDH business will continue to grow as a result of:

1. Customer focus
2. Broad product mix
3. Surface science research
4. Applications expertise
5. Technical resources and support
6. Organizational strength
7. New product development
8. Multiple production locations
Alumina Trihydrate (ATH) and Magnesium Hydroxide (MDH): Versatile Options for Flame Retardancy

The Color of ATH Has an Impact

Common considerations include:
- Ground, tan ATH
- White ATH
- Color controlled, ground ATH

Over the past two decades, Huber technologists have collaborated with leaders in a variety of industries to identify how ATH and MDH can be formulated for maximum functionality and performance.

- It was Huber that introduced low electrolyte ATH for improved electrical properties and thermoset compound shelf stability
- Mechanically ground, ultrafine ATH as an alternative to fine precipitated ATH
- Low resin demand ATH grades for high loadings in low viscosity unsaturated polyester (UPE) resin systems
- Surface modified ATH

It is Huber Engineered Materials that continues to promote the benefits of particle packing via engineered ATH and MDH materials.

Choosing the Right Flame Retardant and Smoke Suppressant

Key material parameters considered when selecting an ATH or MDH product for your flame retardant formulation include:
- Median particle size
- Particle size distribution
- Surface area and particle morphology
- Surface chemistry
- Color

These product characteristics of the base material will have a direct effect on the compounding process and the end properties of your compound. Various types and levels of surface treatments may be employed to reach a given set of compound performance requirements.

ATH

Here’s how it works: It is the heat sinking and endothermic dehydration characteristics that enables alumina trihydrate to retard the burning of polymers. At approximately 220°C (428°F), about 35 percent of ATH is released in the form of steam. This water vapor quenches the surface of the surrounding materials while restricting the access of oxygen to the burning polymer. Combustible and potentially toxic off-gases are also diluted by this water vapor.

\[2\text{Al(OH)}_3 \rightarrow \text{Al}_2\text{O}_3 + 3\text{H}_2\text{O}\]

Because alumina trihydrate contains no halogens or heavy metals, it’s better for environmental compliance than flame retardants based on antimony metal or chlorinated and brominated (halogenated) compounds. Arc-track resistance in electrical composites is improved by the use of ATH. The heat generated by high arc temperatures is absorbed by the alumina trihydrate. When endothermic dehydration occurs the water vapor slows the surface degradation of the polymer and the resultant formation of the carbonized film, or track.

- **Flame Retardance**
  - Alternative to halogens
  - Heat removal
  - Smoke suppression through water vapor generation
  - Char formation

- **Pigmentation/Appearance in Molded Parts**
  - High whiteness and brightness
  - Translucency

- **Functional Performance**
  - Physical property attributes
  - Corrosive environment applications
  - Thermal conductivity (thermal stress)

- **Processing**
  - Better wet out, higher loading levels
  - Improved performance through better reinforcement
  - Lower resin demand
Non-Halogenated Flame Retardants

MDH
While ATH is an effective flame retardant / smoke suppressant for many resins, there are limits to its use. The main limitation results from its thermal stability in applications where processing temperatures exceed 220°C (428°F).

Hence the development of magnesium hydroxide, Mg(OH)_2, as a flame retardant. MDH functions in the same manner as ATH, however, there is one important difference: it undergoes endothermic decomposition with water release at 330°C (626°F).

\[ \text{Mg(OH)}_2 \rightarrow \text{MgO} + \text{H}_2\text{O} \]

The endothermic decomposition of Mg(OH)_2 which occurs during combustion is its flame retardant mechanism. For combustion to occur, there must be fuel, oxygen and heat. By absorbing some of the heat, MDH prevents or delays ignition and retards combustion of the polymeric material. The water released during decomposition has the effect of diluting the combustible gases and acting as a barrier, preventing oxygen from supporting the flame.

Figure one (to the right) compares thermal decomposition characteristics of ATH and MDH. ATH starts to decompose at about 220°C (428°F) while MDH decomposes at about 330°C (626°F). Therefore MDH has a higher thermal stability offering a wider window for compound processing. ATH is suitable for use in thermosets and in certain PVC- and polyolefin-based plastics compounds in which processing temperatures are generally below 200°C. MDH is preferred when formulating plastics compounds that need to be processed at temperatures near or above 220°C (428°F), such as polypropylene and engineering thermoplastics. Using MDH for low-melting thermoplastics or elastomers can also enable higher processing temperatures and increased compounding throughput.

When heated to decomposition, both ATH and MDH release water of hydration that quenches the polymer and dilutes smoke. It is this release water of hydration that quenches the polymer and dilutes smoke. ATH releases about 35% of its weight in water vs 31% for MDH. The process of endothermic decomposition also removes heat thus helping to retard combustion. MDH absorbs more heat (328 cal/g) than ATH (280 cal/g) on the same weight basis. Therefore, higher thermal stability and greater heat removal capacity make MDH a very effective flame retardant.

Physical Property Comparison of Alumina Trihydrate and Magnesium Hydroxide

<table>
<thead>
<tr>
<th>Property</th>
<th>Alumina Trihydrate Al(OH)_3</th>
<th>Magnesium Hydroxide Mg(OH)_2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical Form</td>
<td>Powder</td>
<td>Powder</td>
</tr>
<tr>
<td>Particle Morphology</td>
<td>Hexagonal Platelet</td>
<td>Hexagonal Platelet</td>
</tr>
<tr>
<td>Color</td>
<td>White</td>
<td>White</td>
</tr>
<tr>
<td>Specific Gravity, g/cm³</td>
<td>2.42</td>
<td>2.36</td>
</tr>
<tr>
<td>pH Value</td>
<td>9.10</td>
<td>10.11</td>
</tr>
<tr>
<td>Hardness, Mohs</td>
<td>2.5-3.5</td>
<td>2.0-3.0</td>
</tr>
<tr>
<td>Refractive Index</td>
<td>1.57</td>
<td>1.58</td>
</tr>
<tr>
<td>Temperature of Decomposition</td>
<td>220°C / 428°F</td>
<td>330°C / 626°F</td>
</tr>
<tr>
<td>Heat of Decomposition, cal/g</td>
<td>280</td>
<td>328</td>
</tr>
<tr>
<td>Theoretical Loss on Ignition, %</td>
<td>34.6</td>
<td>31.0</td>
</tr>
</tbody>
</table>
## Typical Physical Properties of Select Grades

<table>
<thead>
<tr>
<th>Product Brand and Grade</th>
<th>Median Particle Size (µm, Sedigraph)</th>
<th>Surface Area (m²/gm)</th>
<th>Oil Absorption (ml/100g sample)</th>
<th>Free Moisture % (105°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Alumina Trihydrate (ATH)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SB 805</td>
<td>2.6</td>
<td>5</td>
<td>34</td>
<td>0.5</td>
</tr>
<tr>
<td>SB 632</td>
<td>3.5</td>
<td>3.7</td>
<td>32</td>
<td>0.25</td>
</tr>
<tr>
<td>SB 432</td>
<td>9</td>
<td>2.10</td>
<td>28</td>
<td>0.25</td>
</tr>
<tr>
<td>SB 332</td>
<td>11</td>
<td>1.80</td>
<td>27</td>
<td>0.25</td>
</tr>
<tr>
<td>SB 336</td>
<td>15.5</td>
<td>1.30</td>
<td>23</td>
<td>0.25</td>
</tr>
<tr>
<td>SB 222</td>
<td>15.0</td>
<td>1.35</td>
<td>23</td>
<td>0.25</td>
</tr>
<tr>
<td>SB 136</td>
<td>18</td>
<td>1.25</td>
<td>21</td>
<td>0.25</td>
</tr>
<tr>
<td>SB / H 36</td>
<td>25</td>
<td>0.95</td>
<td>-</td>
<td>0.13</td>
</tr>
<tr>
<td>Micral® 9400D</td>
<td>1</td>
<td>4.5</td>
<td>29</td>
<td>0.13</td>
</tr>
<tr>
<td>Micral® 916</td>
<td>1.2</td>
<td>16.2</td>
<td>46</td>
<td>0.95</td>
</tr>
<tr>
<td>Micral® 932</td>
<td>2.1</td>
<td>12.4</td>
<td>38</td>
<td>0.8</td>
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<tr>
<td>Micral® 632</td>
<td>3.5</td>
<td>7.8</td>
<td>32</td>
<td>0.60</td>
</tr>
<tr>
<td>Micral® 532</td>
<td>5</td>
<td>6.4</td>
<td>31</td>
<td>0.60</td>
</tr>
<tr>
<td>OnyxElite® 432</td>
<td>8</td>
<td>2</td>
<td>28</td>
<td>0.25</td>
</tr>
<tr>
<td>OnyxElite® 431</td>
<td>8</td>
<td>2</td>
<td>28</td>
<td>0.25</td>
</tr>
<tr>
<td>OnyxElite® 336</td>
<td>15.5</td>
<td>1.5</td>
<td>23</td>
<td>0.25</td>
</tr>
<tr>
<td>OnyxElite® 339</td>
<td>15.5</td>
<td>1.3</td>
<td>23</td>
<td>0.20</td>
</tr>
<tr>
<td>OnyxElite® 255</td>
<td>20</td>
<td>1.5</td>
<td>18</td>
<td>0.20</td>
</tr>
<tr>
<td>OnyxElite® 111</td>
<td>35</td>
<td>0.5</td>
<td>11</td>
<td>0.20</td>
</tr>
<tr>
<td>OnyxElite® 150</td>
<td>50</td>
<td>0.5</td>
<td>10</td>
<td>0.10</td>
</tr>
<tr>
<td>OnyxElite® 103</td>
<td>70</td>
<td>0.3</td>
<td>10.5</td>
<td>0.10</td>
</tr>
<tr>
<td><strong>Magnesium Hydroxide (MDH)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vertex® 100</td>
<td>0.8</td>
<td>15</td>
<td>-</td>
<td>0.5 max.</td>
</tr>
<tr>
<td>Vertex® 60</td>
<td>1.5</td>
<td>13</td>
<td>30</td>
<td>0.5 max.</td>
</tr>
<tr>
<td>Zerogen® 50</td>
<td>0.9</td>
<td>7</td>
<td>-</td>
<td>0.5 max.</td>
</tr>
</tbody>
</table>

**Trademark Identification System**

- **SB**: Standard grades of alumina trihydrate
- **Micral®**: Ultrafine alumina trihydrate
- **Hymod®**: Surface modified alumina trihydrate
- **Zerogen®**: High purity magnesium hydroxide
- **Onyx Elite®**: High brightness alumina trihydrate
- **Hydrad®**: Ultrafine alumina trihydrate for paper applications
- **PATH®**: Alumina trihydrate for paint and coatings applications
- **Vertex®**: General purpose magnesium hydroxide
- **Granite Elite®**: Granite-effect filler for cast polymers
- **Marble Elite®**: Textured pigments for under-gel-coat color/patterns in cast polymer applications

*All specifications are typical. For detailed product specification, please consult your sales representative or download additional information on www.hubermaterials.com.
Variety: Surface Treatments for Increased Performance

To enhance the overall performance of ATH and MDH filled compounds, Huber developed a broad line of surface modifications to aid processing or to improve physical, electrical, flame or chemical resistance properties.

Hymod® ATH offers a number of advantages over untreated grades with similar particle size characteristics. In applications requiring stringent fire retardancy / smoke suppression, Hymod ATH may permit substantially higher loading levels – up to 70%. This provides enhanced performance with minimum deterioration of mechanical properties.

**Higher Loading - Up to 70%**

**Improved Flame Retardancy / Smoke Suppression**

**Lower Viscosity**

**Increased Productivity / Throughput**

**Ease of Dispersion / Increased Uniformity**

**Enhanced Mechanical Properties**

**Improved Water Resistance**

**Chemical Coupling**

**Improved Thermal Stability**

**Improved Heat Aging Properties**

### Recommended Applications for Surface-Treated Hymod® Alumina Trihydrate and Magnesium Hydroxide

<table>
<thead>
<tr>
<th>Surface Modification</th>
<th>Base</th>
<th>Polymer Type</th>
<th>Properties Affected</th>
</tr>
</thead>
<tbody>
<tr>
<td>SP Silane</td>
<td>ATH, MDH</td>
<td>Acrylic, EPDM, EPR, Neoprene, Polyester, Polyolefins, SBR, Silicone Elastomers</td>
<td>Improved mechanical properties; increased water resistance; improved low temperature properties</td>
</tr>
<tr>
<td>Hyflex Silane</td>
<td>ATH</td>
<td>Epoxy, Polyester, Urethane</td>
<td>Lower viscosity allows for higher loading level</td>
</tr>
<tr>
<td>SH-2 Silane</td>
<td>ATH</td>
<td>Epoxy, Polyester, Urethane</td>
<td>Lower viscosity allows for higher loading level; polymer compatibility, hydrophobicity</td>
</tr>
<tr>
<td>SA Silane</td>
<td>ATH, MDH</td>
<td>Nitrile, Phenolic, PVC, Urethane, Polyamids, Epoxy, Polyolefins</td>
<td>Improved low temperature properties, better flame retardancy</td>
</tr>
<tr>
<td>SE Silane</td>
<td>ATH</td>
<td>Epoxy, Phenolic</td>
<td>Lower viscosity allows for higher loading level; better air release, improved water resistance.</td>
</tr>
<tr>
<td>SC Silane</td>
<td>ATH</td>
<td>Acrylic, EPDM, Polyester, SBR, Nitrile</td>
<td>Improved resistance to stress whitening.</td>
</tr>
<tr>
<td>SF Silane</td>
<td>ATH, MDH</td>
<td>PVC</td>
<td>Improved water resistance, improved dynamic thermal stability.</td>
</tr>
<tr>
<td>CM Surfactant</td>
<td>ATH</td>
<td>Epoxy, Phenolic, Urethane, Polyester</td>
<td>Lower viscosity allows for higher loading level; rapid and complete dispersion.</td>
</tr>
<tr>
<td>ST Stearate</td>
<td>MDH</td>
<td>Polyolefins</td>
<td>Improved processing for high throughput applications.</td>
</tr>
<tr>
<td>SL Stearate</td>
<td>ATH</td>
<td>Polyolefins</td>
<td>Improved dispersion for high loading applications.</td>
</tr>
<tr>
<td>PK Polymer</td>
<td>ATH, MDH</td>
<td>Polyolefins</td>
<td>Improved color, improved mechanical properties.</td>
</tr>
</tbody>
</table>
PRODUCT AND APPLICATION DEVELOPMENT/TESTING CAPABILITY

Product development and testing
• Flame retardant compound formulating
• Laboratory and pilot scale compounding and extrusion
• High-shear mixers for FR additive surface treatment
• Complete testing on material intrinsic and mechanical properties
• Gel and cure testing for thermoset resins
• Thermal and rheological characterization
• Environmental weathering
• Electrical testing
• Complete analytical testing

FIRE TESTING CAPABILITY
• ASTM E1354: Cone Calorimeter
• ASTM E662: NBS Smoke Chamber
• ASTM D3806: Two-Foot Tunnel
• ASTM D2863: Limiting Oxygen Index
• UL 94 Horizontal and Vertical Burn Tests
• ASTM E648: Radiant Panel
A Multi-Mineral Approach

Huber’s ATH and MDH business is growing thanks, in part, to the knowledge and manufacturing expertise gained through innovations in a variety of other inorganic powders.

Formulators looking for consistency and purchasing managers striving for single-stop mineral acquisition can benefit by working with Huber. Here is an example of the variety of products Huber offers:

**Calcium Carbonate**
Huber markets calcium carbonate in many forms. It is widely used and has versatile physical characteristics and can be used in broad formulations. All of Huber’s industrial calcium carbonate is processed from natural limestone sources – making it one of the purest and brightest forms available. Its low cost, low oil absorption and particle size range consistently has this mineral ranked high in total volume sold annually.

**Silica and Silicates**
Huber’s engineering expertise in precipitated silica is widely recognized as best in class. Its thixotropic and rheologic value is recognized worldwide.
Facts
Alumina trihydrate is the largest volume flame retardant used in the world.
Technically known as aluminum hydroxide, ATH has a chemical formula of Al(OH)₃.
In March 2005, The Freedonia Group reported that ATH will continue to be
the largest volume flame retardant...because of its low cost and wide range of uses.
[Source: Chemical Market Reporter, March 2005].

Partnership: A collaboration of technical leadership and application expertise
At Huber Engineered Materials, we strive to
unite deep technical understanding with applications expertise.
Formulation versatility and lot-to-lot consistency
are hallmarks of Huber’s products. Our broad
product line assures formulation ease and property improvements
in many products and application types that require:

- Halogen-free or low halogen flame retardance
- Low smoke / Smoke suppression
- Resin extension / Cost reduction
- Thermal stress reduction
- Dimensional stability
- Chemical resistance
- Improved electrical properties
- Optical properties

Listed below are application snapshots
describing some of the diverse markets served
by Huber Engineered Materials and our ATH
and MDH products. Over the years, Huber
has enjoyed many, many mutually rewarding partnerships with manufacturers within these
major market categories.

Wire and Cable
ATH and MDH are widely used to make
low-smoke, halogen-free flame retardant wire
and cable compounds for insulation and jacketing
applications. Huber offers a broad product
assortment of grades for flame retardance and
smoke suppression to satisfy the needs of wire
and cable compounders and producers. Huber’s
grades are used in building wire, power/utility
cable and accessories, electrical and electronic
cable, transportation cable, mining cable,
communications/data cable, automotive wire
and appliance cable applications.

Thermoplastics
ATH and MDH are rapidly growing as FR
additives in thermoplastic materials. Typical
applications include polypropylene modified
roofing tiles, polyolefin-based tubing and pipe,
polyamide electrical fixtures and components,
flame retardant parts for automotive, transit,
military and marine uses, and specialty films
and membranes.

While ATH and MDH containing systems can
offer the compounder improved economics over halogenated FR systems, there are other benefits
as well. ATH and MDH are not corrosive to
processing equipment and machinery. Since some
of these synergists also contain elements that are
regulated under Sara Title III, arsenic for example,
the compounder realizes yet another benefit by
eliminating a reportable item.

From the formulator, to the compounding, to the
producer of finished goods, ATH and MDH systems
have a lot to offer the thermoplastics market.

Building Materials - Roofing and Siding
Huber’s ATH and MDH additives are used in a
variety of building materials - roofing products
being the largest consumer. Our ATH and MDH
additives are used in latex roof coatings, in
asphalt based roofing products, in rubber based
(EPDM primarily) membranes and in polymeric
(TPO membranes primarily) based systems.

Huber’s capabilities and facilities are unmatched
in the industry. Huber’s comprehensive knowledge
and unique application knowledge advance the
art of flame retardant compounding formula-
tions and extrusion processing. Our thorough
in-house fire testing, for all types of roofing
formulations, aids our customers in producing
consistent products for their marketplace. ATH and MDH additives provide utility to the formulator as they add a multitude of properties, among them: fire resistance, high color, non toxicity, non corrosiveness and formula compatibility. Huber’s Vertex 60HST magnesium hydroxide is the industry standard for single ply TPO membranes and Vertex 60ST the industry standard for EPDM membranes.

Reinforced Plastics/FRP
Huber is North America’s leading supplier of ATH and Hymod surface modified ATH to compounders and molders of filled polyester resin systems. Major applications within this important market segment include:

- SMC and BMC compounds
- Pultrusion
- Electrical flat sheet
- Continuous panel
- Spray-up
- Hand lay-up
- Cured-in-place pipe

When used in compression, injection or pultruded compounds Huber’s ATH products deliver outstanding benefits to the formulator. A wide range of consistent quality, low resin demand products with excellent surface chemistry and color provide our customers with complete compounding flexibility. Huber’s selectively chosen ATH feedstocks are processed using a variety of milling techniques which yield a myriad of particle distributions that can be used individually or in combination for maximum loadings with optimized processing, mechanical, flame and electrical properties.

Carpet Backing
All carpet sold in the United States must meet Federal flammability standards. In addition, local and regional standards may also exist and local fire marshals have the authority to establish strict criteria for compliance.

Flame and smoke requirements also vary according to the end use of the carpet itself. For example, carpet intended for use in high traffic areas like schools, health care facilities, hotels and other types of commercial venues are required to meet more strict requirements than carpet intended for less public uses.

Various methods of meeting these requirements are formulated in carpet production including the use of alumina trihydrate in backing compounds. ATH is non-abrasive and non-halogenated; it is available in particle size distributions that allow backing compounders to use high loading levels in their formulations. ATH is a highly effective, economical, and easy to use formulation option to meet the flame retardant/smoke suppression goals of the carpet manufacturer.

Cast Polymers
The manufacturing of polyester and acrylic counter-tops, bath tubs, shower walls and sink basins requires a high quality, a versatile alumina trihydrate. Huber’s history of delivering consistency batch-to-batch is exemplified in its long-standing relationships with customers large and small. From multi-national manufacturers to regional cast polymer experts, Huber’s product delivers each and every time.

- Onyx Elite® ATH: highly translucent, sintered white and color controlled ATH products for the manufacture of cultured onyx or densified solid surface. This product line offers excellent color, translucency, low resin demand and outstanding air release properties.
- Granite Elite® textured pigments: a single bag, engineered composition of pigmented polyester granules and specially selected ATH grades for the manufacture of densified solid surface or cultured granite products. Granite Elite is noted for its high chip density, excellent depth of detail, consistency of color and low resin demand. Huber features over 60 colors in its current Commercial, Premium, Peak and Summit series of Granite Elite products. Color brochures available.
- Marble Elite® Granite: based on our high brightness calcium carbonate and pigmented polyester chips, this engineered composition provides an excellent value to those producers manufacturing gel coated cultured granite.

Epoxy potting and encapsulation is a cast polymer application which has long utilized the ATH products of Huber. Improved flame and electrical properties result from highly filled systems featuring low resin demand and excellent suspension characteristics.

General Rubber Goods
Silicone rubber: ultrafine surface modified ATH imparts flame and electrical properties. Silane surface modification improves ATH dispersion, lowers compound viscosity and cost while increasing mechanical properties of the silicone rubber compound.

Foam rubber: fine to medium fine grades of ATH have long been used to produce flame retardant, smoke suppressed grades of neoprene foam products used in commercial cushioning materials.

General rubber goods: from gasketing materials to mine belts, fine to medium fine grades of ATH are used to impart flame and smoke properties to those rubber products that must meet certain fire safety standards.

Caulks, Sealants, Adhesives
Huber’s multi-functional ATH products provide the manufacturers of these materials with a variety of improved processing and performance characteristics resulting from unique properties attributed to the type, shape and particle distribution of the ATH chosen. Reduced flame and smoke, color, Moh hardness and FDA approval for food contact all are reasons why ATH is used in these applications.
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Zerogen® is a registered trademark of J.M. Huber Corporation for magnesium hydroxide.

Vertex® is a registered trademark of J.M. Huber Corporation for magnesium hydroxide.

Granite Elite® is a registered trademark of J.M. Huber Corporation for granite-effect filler for cast polymers.

Marble Elite® Granite is a registered trademark of J.M. Huber Corporation for pigments for under-gel-coat color/patterns in cast polymer applications.